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Distribution and conservation status of the Giant Sweet Potato, a rare Aboriginal food plant from Central Australia

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Abstract

The Giant Sweet Potato, *Ipomoea polpha* subsp. *latzii* R.W.Johnson (Convolvulaceae), or "Antjulkinah", is a rare plant endemic to central Australia, and features prominently in the mythology of the Traditional Owners of the area, the Anmatjerre people. The taxon is known from three sub-populations and has a highly restricted geographic distribution. Our study of the distribution, density and population size of *Ipomoea polpha* subsp. *latzii* incorporated traditional ecological knowledge, and led to the identification of an additional extensive sub-population. The distance-transect method was used to calculate estimates of population size and density for the Giant Sweet Potato, and is one of the only published examples of the application of this method to a plant species. We estimate the area of occupancy of the taxon to be at least 26.7 km^2, significantly greater than the population estimate reported by a survey in 1987. Our data support listing the species as Vulnerable under IUCN (2008) criterion D2.

Introduction

Limited resources are available for the management of threatened plant species. Prioritization of these resources may be achieved by ranking species according to their perceived threat of extinction. The IUCN criteria (IUCN 2008) are widely used in Australia, by state, territory and federal governments, to assess the conservation status of species and to assign a ranked category of extinction risk. Distribution and abundance data for taxa are required to make an assessment, and these data are frequently costly and time-intensive to collect. The conservation status of many plant

species in Australia has yet to be determined. For example, in the Northern Territory, of the 4,502 recognised taxa, 707 taxa (15.7%) are so poorly known they have been assigned to the category of "data deficient" (NRETAS 2009). New or alternative methods to collect information on density, distribution and population size of species in an accurate and cost effective way would be of value and could be used to augment more commonly used survey techniques. One such method is the incorporation of traditional ecological knowledge (TEK) into projects assessing the conservation status of species.

Traditional ecological knowledge is defined as the knowledge base acquired by indigenous people over long time periods through direct contact with the environment and includes detailed knowledge of plants, animals and natural phenomena (Bourque *et al.* 1993). Indigenous knowledge can be used to assist in the assessment of the conservation status of rare species by providing information on distribution, density and population size. For example, TEK has been used to delineate the distribution of several rare Australian mammals (see for example Burbidge *et al.* 1988; Baker *et al.* 1993; Pearson & the Ngaanyatjarra Council 1997; Telfer & Garde 2006). Some rare plant and animal species may be of cultural importance to Aboriginal people and should be prioritized for the collection of TEK and for assessment of conservation status.

Ipomoea polpha subsp. *latzii* (Convolvulaceae), the "Giant Sweet Potato", is a rare plant endemic to Central Australia. The two other disjunct, but more widespread, subspecies of *I. polpha* occur in Queensland (Johnson 2006). Plants develop multiple edible tubers (Figure 1), most of which are of similar size to or smaller than the commercial sweet potato (*Ipomoea batatas*). However, some tubers can be enormous. The largest tuber weighed by Soos and Latz (1987) was 2.6 kg. The Giant Sweet Potato is called "Antjulkinah" by the Anmatjerre, the local indigenous people, and features strongly in their mythology. The Anmatjerre people have songs for locating the plants and for "singing him up" (Soos & Latz 1987). The tubers are easily excavated from the sandy soil and roasted on coals or eaten raw, tasting similar to a water chestnut. The Giant Sweet Potato is known to several other groups in the surrounding area (for example Kaytej, Warlpiri and western Alyawarra), although the taxon is not known to occur in these areas (Soos & Latz 1987). *Ipomoea polpha* subsp. *latzii* is thought to have been traded with these and other groups, and to have been eaten during gatherings for ceremonies (Soos & Latz 1987).

A survey in 1987 (Soos & Latz 1987) indicated that the taxon was restricted to an area of approximately 9 by 13 km with an estimated population of 11,000 individuals. The then undescribed taxon (*Ipomoea* A83192 Stirling) was coded as Vulnerable at a national level under the *Environment Protection and Biodiversity Conservation Act* (1999). Potential threats proposed by Soos and Latz (1987) included fires, drought and changes to hydrology. Since 1987 no scientific monitoring of the species had been conducted and extensive bushfires burnt sections of the known distribution of the

species in the winter of 2001. Field work for the present study was conducted in 2005 following 18 months of drought in Central Australia (Australian Bureau of Meteorology 2010).

Figure 1. The Giant Sweet Potato or Antjulkinah, *Ipomoea polpha* subsp. *latzii* (Convolvulaceae): A. inflorescence (Peter Latz); B. tubers (Antal Soos); and C. tillers (dying back) and some of the Anmatjerre people (Andrew Rayner).

Importance to the local indigenous community, narrow geographic range of the taxon and few recorded localities prompted the selection of *Ipomoea polpha* subsp. *latzii* R.W.Johnson (Convolvulaceae) for this study. Here we incorporate TEK into the study of the Giant Sweet Potato as it is a plant of utilitarian and cultural significance to the Anmatjerre people. We re-map the extent of *Ipomoea polpha* subsp. *latzii*, calculate population density and size, and compare these to values recorded 18 years prior. We use the data collected to review the conservation status of the taxon under the IUCN guidelines (2008).

Methods

Study species

Ipomoea (Convolvulaceae) is a genus of approximately 500 species globally (Harden 1992). Thirty-three *Ipomoea* species are endemic to Australia and another 17 are naturalised (ANBG 2010). *Ipomoea* species produce large colourful blooms, two of which were illustrated during the voyage of Captain James Cook on the Endeavour (Ebes 1988). *Ipomoea* species are a major carbohydrate source across the Pacific region and throughout the tropical world (Woolfe 1992). A single species, *I. batatas*, is cultivated in more than 100 countries and is the seventh most common food crop in the world, by weight of annual global production (Woolfe 1992). Several species are of commercial value in Australia and are grown as both ornamentals and food crops (Harden 1992). For thousands of years the tubers of *Ipomoea* plants have been harvested for food by Aboriginal people in Australia, including in arid areas (Isaacs 1987; Wightman *et al.* 1992; Latz 1995; Nambatu *et al.* 2009).

Ipomoea polpha subsp. *latzii* was recently described by Johnson (2006). The inflorescence is deep pink with a darker, maroon throat (Figure 1A), although occasionally the species is seen with a white corolla. The plant is perennial, although prostrate runners to 4 m long die back annually (Figure 1C). Tubers enable plants to survive unfavourable conditions, re-sprouting with rain, which falls mostly during summer. The Giant Sweet Potato has been grown at the Alice Springs Desert Park, and seems to be reasonably easy to propagate.

Study site

Ipomoea polpha subsp. *latzii* occurs in an area approximately 200 km north of Alice Springs in central Australia. The area is dominated by Mulga (*Acacia aneura*) and Witchetty (*A. kempeana*) open woodland/shrublands. Mean annual rainfall for the area is 324 mm, falling mostly between November and February (Australian Bureau of Meteorology 2010). From October to March, maximum daily temperatures can be above 40°C, and from June to August minimum daily temperatures can be below 0°C with occasional frosts (Australian Bureau of Meteorology 2010). The soil is a red sandy clay loam with occasional clay pans in low lying areas (Soos & Latz 1987). Soil samples from areas supporting *Ipomoea polpha* subsp. *latzii* and from other localities in

the region did not differ appreciably in pH, electrical conductivity or nutrient content (Soos & Latz 1987).

Mapping distribution

Areas where the Giant Sweet Potato occurs differ only subtly in topography, vegetation type and soil physicochemical properties (Soos & Latz 1987). The open woodland habitat extends for hundreds of kilometres through Central Australia and there is no clear difference between areas where the *Ipomoea* is present or absent. Due to subtle differences in physical and environmental conditions, construction of a distributional model is problematic. To overcome this limitation, TEK of the local Anmatjerre people was used in the search for the rare plant.

Senior Anmatjerre Traditional Owners participated in three field excursions between April and July, 2005, of between one and three days each, to Ahakeye Aboriginal Land Trust, Stirling and Anningie stations. Between three and 17 informants participated in each trip. Informal group discussions were initiated using a large format book summarizing research previously conducted and Traditional Owners took the group to locations where they knew the Giant Sweet Potato to occur (including one previously unrecorded sub-population). A representative from the Central Land Council (CLC) accompanied the group during all three consultations, and protocols for collecting Aboriginal knowledge were guided by CLC staff. Information of religious or cultural significance was recorded by the CLC representative, under the direction of the Traditional Owners, and is retained by the CLC on behalf of the Anmatjerre people. The aim of the consultations was initially to explain the proposed survey and to seek permission for access from Traditional Owners, and subsequently to circumscribe the distribution of the *Ipomoea polpha* subsp. *latzii* sub-populations.

Estimating density and abundance

The distance-sampling method (see Buckland *et al.* 1993; Burnham & Anderson 1998; Thomas *et al.* 2010) was used to estimate the density and abundance of Giant Sweet Potato plants. Observations were made by following a transect and recording the distance from the transect to each *Ipomoea* plant observed. These measurements were used to derive a probability of detection, that is, a model of the distribution of observations as distance from the transect increases. Eleven transects in total were established. The three sub-populations of the Giant Sweet Potato are referred to here as Tinfish-Low Level, Atatirk and Long Range (Figure 2). Transects for the Tinfish-Low Level and Atatirk sub-populations were east-west oriented. For the Tinfish-Low Level sub-population, surveys were conducted along four parallel transects 500 m apart in the northern section, and four at 1,000 m spacing in the southern section. Two transects 1,200 m apart were surveyed in the Atatirk sub-population. One north-south oriented transect was surveyed in the Long Range sub-population. Transects began and ended at least 300 m outside the mapped sub-populations in order to accurately detect and map the edge of the distribution.

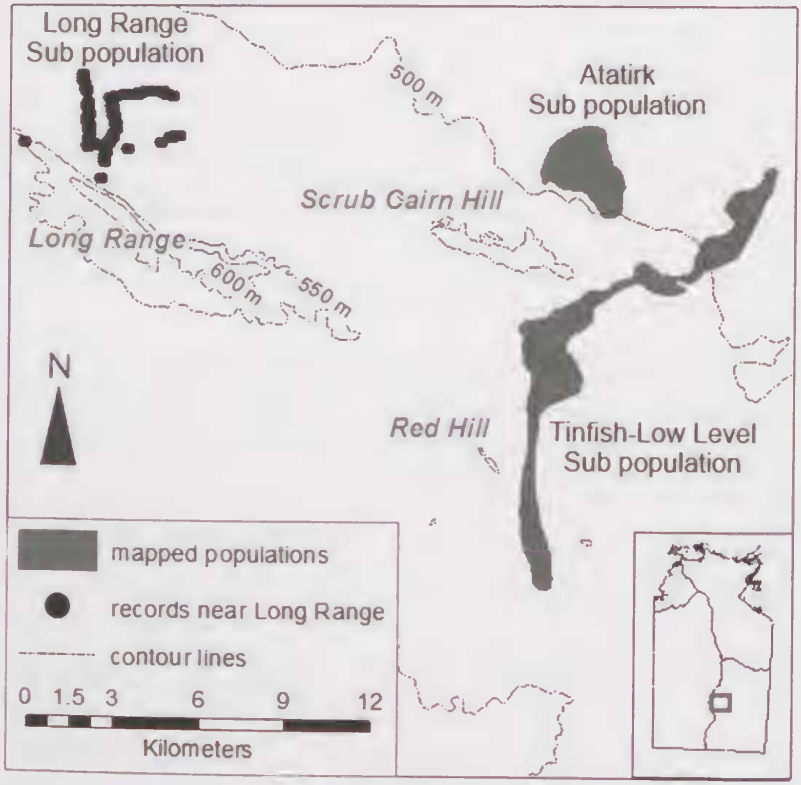

Figure 2. Known locations of *Ipomoea polpha* subsp. *latzii*. Black dots indicate records within the previously unrecorded Long Range sub-population. Inset shows the Northern Territory, Australia with study site indicated by box.

The perpendicular distance from the transect to the centre of each *Ipomoea* plant visible from the transect was recorded to the nearest 10 cm with a tape measure. Although almost all above ground material was dead, the plants were clearly visible from up to 40 m away, as plant crowns were frequently more than one metre in diameter with runners originating from the central part of the plant and scrambling over fallen branches and debris for several metres (Figure 1C). A GPS and compass were used to maintain transects on an accurate bearing and to delineate sub-population boundaries.

The density and abundance of plants were calculated for the three sub-populations with DISTANCE v5 software (Thomas *et al.* 2010). The data were truncated by removing the most distant 5% from each sub-population dataset as recommended by

Buckland *et al.* (1993). Models of the detection function were ranked based on the Akaike's Information Criterion (AICc), chi-square scores and the coefficient of variance (Buckland *et al.* 1993, Burnham & Anderson 1998). A relative difference of two or greater in AICc scores between models demonstrates a clear difference between models, and the model with the lowest AICc was selected. AICc rather than AIC scores were used to rank models, as is recommended by Burnham and Anderson (1998) when sample sizes are small.

Results

Aboriginal Traditional Owners guided the group to a previously unrecorded sub-population of *Ipomoea polpha* subsp. *latzii* (Figure 2). This sub-population, referred to here as "Long Range", is approximately 14 km to the west and slightly north of the Atatirk and Tinfish-Low Level sub-populations. The extent of the Long Range sub-population has yet to be mapped, but adds significantly to the documented distribution of the plant. This sub-population is at least as large as the Atatirk sub-population. The Tinfish-Low Level sub-population boundary was extended by almost 4 km to the south (Figure 3), and covers 1,462.2 hectares (Table 1). The extent of the Atatirk sub-population was extended to the south, east and west (Figure 3), and was 605.9 hectares (Table 1). The area of the Atatirk sub-population was extended by 35%, and that of the Tinfish-Low Level sub-population by 48%, when compared to the 1987 survey of Soos and Latz (1987).

A total of 14.2 kilometres of transect were surveyed within the *Ipomoea* sub-populations, and 1,524 individuals recorded (Table 1). Three detection functions were developed for each sub-population, all with similar AICc, chi-square scores and coefficients of variance (Table 2). High chi-square values indicate a good fit between the statistical distribution predicted by the model and the actual distribution of plants. The coefficient of variance indicates the variance recorded between transects within each sub-population and differed little between models.

Within each sub-population, density estimates of each model were similar, and the density of plants in the Tinfish-Low Level and Atatirk sub-populations did not differ significantly (Table 3). Density estimates ranged from 19.3 to 65.4 individuals per hectare for the Tinfish-Low Level sub-population, and from 18.7 to 48.4 for Atatirk. The Long Range density estimates are based on a single transect and cannot be assumed to represent the sub-population as a whole. Density was higher than for the other sub-populations, and ranged from 43.5 to 72.2 plants per hectare.

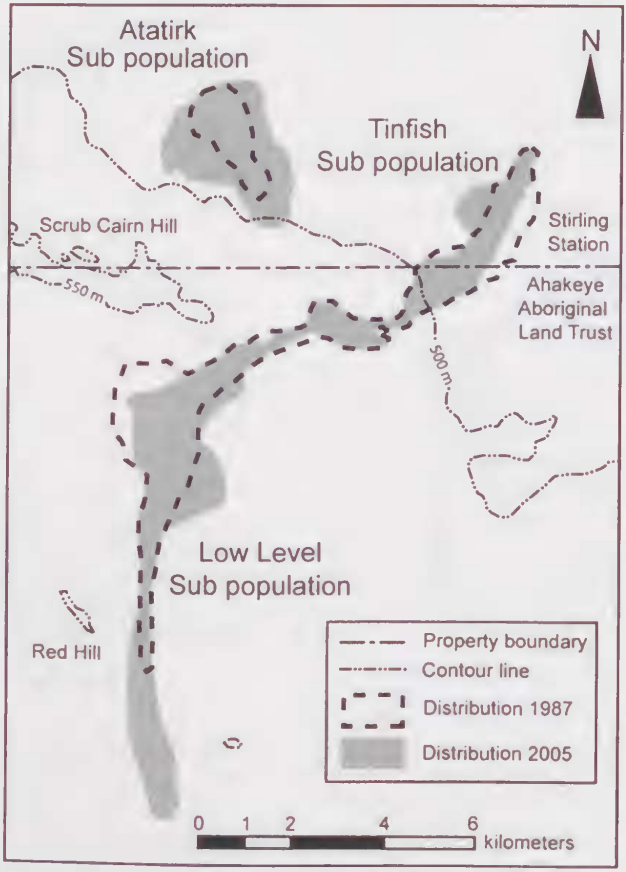

Figure 3. Distribution of *Ipomoea polpha* subsp. *latzii* mapped by Soos & Latz (1987) and during the present study in 2005.

Table 1. Area of *Ipomoea polpha* subsp. *latzii* sub-populations, with numbers and lengths of transects, and numbers of plants counted.

Sub-population name	Area (ha)	No. of transects	Total transect distance (m)	No. of plants recorded
Tinfish-Low Level	1,462.2	8	9,997	1,208
Atatirk	605.9	2	3,153	208
Long Range	>605.9	1	1,091	108
Total	**>2,674.0**	**11**	**14,241**	**1,524**

Table 2. Models selected for the Tinfish-Low Level, Atatirk and Long Range sub-populations of *Ipomoea polpha* subsp. *latzii*. Models are ranked by AICc.

Sub-population / Model	No. of parameters	AICc	ΔAICc	Goodness of fit (*P* for chi-square)	Δ coefficient of variance
Tinfish-Low Level					
Hazard rate, cosine	3	7,084.78	0	0.09	0.264
Half normal, cosine	2	7,085.02	0.24	0.07	0.267
Uniform, hermite polynomial	2	7,086.03	1.25	0.06	0.263
Atatirk					
Half normal	1	914.11	0	0.70	0.21
Uniform, cosine	1	914.63	0.52	0.68	0.21
Hazard rate	2	916.62	2.51	0.60	0.21
Long Range					
Uniform, hermite polynomial	2	492.02	0	0.149	0.111
Half normal, hermite polynomial	1	492.35	0.33	0.274	0.104
Hazard rate	2	493.72	1.37	0.112	0.154

Table 3. Density and abundance estimated for *Ipomoea polpha* subsp. *latzii* in the Tinfish-Low Level, Atatirk and Long Range sub-populations. Population size not calculated (n.a.) for the Long Range sub-population as it is yet to be mapped accurately. CI: confidence interval.

	Density (per ha)		Population	
Sub-population	**Mean**	**95% CI**	**Estimate**	**95% CI**
Tinfish-Low Level	35.5	19.3–65.4	51,972	28,250–95,615
Atatirk	30.1	18.7–48.4	18,230	11,329–29,335
Long Range	56.1	43.5–72.2	n.a.	n.a.

The total population size of Tinfish-Low Level was estimated to be between 28,250 and 95,615 individuals, and the Atatirk sub-population between 11,329 and 29,335 plants. The population size has not been quantified for Long Range as the distribution of the sub-population has yet to be delineated. We estimate it to exceed the Atatirk sub-population.

Discussion

A new sub-population of the rare *Ipomoea polpha* subsp. *latzii* was identified with the assistance of the Anmatjerre Traditional Owners, thus improving the knowledge base used for assessing the conservation status of the taxon under the IUCN guidelines. Estimates of population size and density of the Giant Sweet Potato were made by applying the distance sampling technique (see Buckland *et al.* 1993; Thomas *et al.* 2010). This study is an uncommon example of application of this method to a plant, rather than an animal, taxon. The total number of individuals, the density and the area of occupancy of the Giant Sweet Potato were greater in 2005 than in 1987, indicating that the population has not declined in the intervening 18 years, despite fires and a recent 18 month drought.

The total number of Giant Sweet Potato plants in the two comprehensively mapped sub-populations ranged from 39,579 to 124,950 individuals, substantially greater than the previous estimate of 11,000 (Soos & Latz 1987). This greatly increased estimate of population size can be attributed to delineation of a larger extent of occupancy and to increased density of plants. The estimated density of *Ipomoea polpha* subsp. *latzii* individuals was higher in 2005 than in 1987. The estimated average density of the Atatirk sub-population was 1 mature plant per hectare in 1987 (Soos & Latz 1987), and between 18.7 to 48.4 plants per hectare in the present study. Soos and Latz (1987) did not describe their methods for calculating density, nor provide confidence intervals for their estimates. However, as the densities calculated in the present study are many times higher, it is likely that at least some of this increase is due to recruitment and not to differences in methodology. The mapped areas of occupancy of the previously mapped sub-populations of the Giant Sweet Potato (Tinfish-Low Level and Atatirk) were also substantially greater in 2005. A large range extension was recorded in the present study in the area south of the Tinfish-Low Level sub-population, and the distribution of the Atatirk sub-population was greater in most directions.

Although an 18 month drought preceded the present study, actively growing Giant Sweet Potato plants were observed during a preliminary trip in March of 2005 which followed substantial rainfall on 3-4 January 2005 (82 mm at Tinfish Well; Bill Sage, pers. comm.). Several episodes of recruitment are likely to have occurred during the 18 years between the surveys and are likely to be associated with periods of high rainfall. Continued monitoring of *Ipomoea polpha* subsp. *latzii* could provide evidence of the role of precipitation in recruitment and range expansion of this taxon. Understanding the drivers of local recruitment dynamics would enable an assessment to be made of population stability and could lead to identification of factors (or combinations of factors) limiting recruitment.

Conservation status

Based on new information from this study, the conservation status of *Ipomoea polpha* subsp. *latzii* was assessed against the IUCN Guidelines (2008), and the taxon qualifies for the category of Vulnerable. The IUCN (2008) criteria for "Vulnerable" section D has three elements which relate to (i) the number of mature individuals (D1), (ii) area of occupancy (D2) and (iii) number of known localities of the taxon (also D2). Under section D1 a population with fewer than 1,000 reproductively mature individuals is classified as Vulnerable. The total population of *Ipomoea polpha* subsp. *latzii* is well above this threshold, and is estimated (for the Tinfish-Low Level and Atatirk sub-populations) to be between 39,579 and 124,950 individuals. Although this estimate includes all individuals, rather than only reproductively mature plants, it greatly exceeds the D1 threshold. In addition, the recently located Long Range sub-population has not been included in this estimate, and is likely to contribute significantly to total population size and to the number of reproductively mature individuals. Under Vulnerable criterion D2, a taxon with an area of occupancy less than 20 km^2 is classified as Vulnerable. The Giant Sweet Potato has area of occupancy at least 26.7 km^2, and cannot be considered Vulnerable under this criterion. The Giant Sweet Potato does, however, fulfill the second element of criterion D2, as it is known from fewer than five localities. As the Giant Sweet Potato is a conspicuous taxon and is well known to the local Traditional Owners, there is a level of confidence that the plant is restricted to the three sub-populations described here. During consultation with the local people it seemed, anecdotally, that visiting locations where the Giant Sweet Potato occurs is an infrequent event, and some of the participants had not visited the area for more than ten years. The impact of harvesting the Giant Sweet Potato for food by the local Traditional Owners is considered to be extremely low, and highly unlikely to impact on the population size and persistence of this rare plant. The taxon should be classed as Vulnerable (IUCN 2008) under criterion D2 at a regional, national and global level.

Sampling methods and limitations

Although TEK has been recognized as a useful resource (Hanks 1984; Ross *et al.* 1994; Horstman & Wightman 2001) it has been utilized in few published studies (Huntington 2000; Horstman & Wightman 2001). Species currently coded as data deficient can be difficult to code under the IUCN guidelines. The limited number of localities of occurrence of the target species may be an artifact of sampling bias (either spatially or temporally), or the inherent cryptic nature of some taxa. Where the target species is known to local Aboriginal people such issues can be overcome, as they were for the Giant Sweet Potato. *Ipomoea polpha* subsp. *latzii* is culturally significant to the Anmatjerre people, and we were able to work with Traditional Owners who had direct knowledge of the distribution of the plant. Invaluable distributional information on the taxon was collected and used to target the field surveys. An additional and extensive sub-population was located by the Traditional Owners, contributing

significantly to the documented geographic range of the taxon, and to estimates of population size. The incorporation of TEK in the present study was especially important due to the lack of obvious environmental correlates that could be used to build a statistical distributional model.

Similar studies of rare plant species could benefit by consultation with local Traditional Owners. Rare taxa are more likely to be culturally important to local indigenous people when the organism (i) has a utilitarian value, such as for food or medicine; (ii) is large, abundant or unusual (Baker *et al.* 1993); (iii) is spiritually significant (Baker *et al.* 1993); or (iv) has a relationship to other important species, for example, if culturally significant animals browse or visit hollows (Nabhan 2000). For rare plant species with any of these four traits, cooperative research with indigenous communities can be developed to collect distributional and ecological data for the species. TEK is specifically referred to in the EPBC Act (1999) in section 3(1)(g) as follows: "The objects of this act are to promote the use of the indigenous people's knowledge of biodiversity with the involvement of, and in cooperation with, the owners of the knowledge." TEK is a resource too valuable to ignore in surveys of rare plants and animals.

Distance-sampling has rarely been used to estimate the abundance of plants, and it has remained largely within the domain of animal ecology (for example see Houndsome *et al.* 2005; Barlow & Taylor 2005; Novak *et al.* 2005). The distance-sampling method has been described by Buckland *et al.* (1993) as ideal for the assessment of plant populations. The assumptions of the methods, which must be met to produce robust estimates, are that: (i) target organisms do not display evasive movement, and, of course, plants always meet this assumption; (ii) the distance to the target organism can be measured with accuracy; and (iii) that every target organism occurring actually on the transect is detected. The detection probability of the *Ipomoea* plants was high due to their large size and clear visibility through the open woodlands. The method has several advantages over plot-based plant survey techniques, as every plant observed can be recorded, not just the individuals within quadrats or belt-transects. This is of particular importance for rare species as a larger number of individuals can be recorded, therefore improving estimates of abundance.

Further research on the Giant Sweet Potato

We recommend mapping the recently located Long Range sub-population of the Giant Sweet Potato, and it would be helpful to invite the Traditional Owners to participate. An on-going monitoring program for the taxon should be implemented, particularly to investigate the role of episodic periods of high rainfall on recruitment, and the potential impacts of wildfire and grazing on the Giant Sweet Potato.

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